

NEW ALLOYS OFFER WIDER RANGE OF PHYSICAL PROPERTIES

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TECHNICAL BULLETIN #226

GENERAL FINDINGS INC.

MAIN PLANT
ATTLEBORO
MASSACHUSETTS

WEST COAST PLANT
7327 LANKERSHIM BLVD.
NO. HOLLYWOOD, CALIF.



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INTRODUCTION

Leach and Garner #226 Alloy is a time tested contact material for long life contact applications. This alloy of the nominal composition:

Palladium	-	35%
Platinum	-	10%
Gold	-	10%
Silver	-	30%
Copper	-	13.75%
Zinc	-	1.25%

has long been accepted in the micro current and potentiometer field for slip ring brushes, contact arms, bus bars and make-and-break application in relays.

This well known and engineer approved alloy has now been made better than ever through minute adjustments of composition, control of impurities and radically improved processing methods. The results of these improvements can readily be appreciated by a comparison of former published data on this alloy with the data herein.

Marketed through General Findings Inc. (affiliate of Leach and Garner Co.), it is available in strip to a minimum thickness of 0.002", in wire to a minimum diameter of 0.004", as well as in a limited range of tubing. General Findings Inc. not only markets material, but fabricates parts to customers' specifications. Most leading manufacturers find it desirable to order finished parts as very few manufacturers have the specialized equipment necessary to produce the precise control over age-hardening that is required to achieve the optimum in physical properties.

PHYSICAL PROPERTIES OF L&G #226

	<u>Solution Annealed</u>	<u>Age Hardened</u>
Resistivity, ohms/cm. nominal	200	180
Temp. Coef. of Resistance / °C (0-100) Nominal	.0003	.0003
Temp. Coef. of Expansion / °C (30-100)	8.5×10^{-6}	8.5×10^{-6}
Density gr. / cc Nominal	11.9	11.9
Dwt. / cu. in. Nominal	125.4	125.4
Fusion Temp. °F Nominal	1975°F	1975°F
Color - Platinum White	Corrosion Resistance - Excellent	

MECHANICAL PROPERTIES OF L&G #226 SHEET & WIRE

SOLUTION ANNEALED

Modulus of Elasticity	17×10^6	
Ultimate Tensile Strength p.s.i.	105,000 -	135,000
Elongation in 2" (Proportional to U.T.S.) Nom.	35%	25%
Proportional Limit (% of U.T.S.)	75%	65%
Grain Size (Equi-Axed Structure)	.005 mm . max	.005 mm . max.
Diamond Pyramid Hardness (200 Gr. Load)	200	230
Knoop Hardness (100 Gr. Load)	210	235
Spring Force Applications	60% of Prop. Limit	
Creep Under Sustained Load within Prop. Limit	NIL	
Angle of Set		12°

DUCTILE GRADE

Modulus of Elasticity		17 x 10 ⁶	
Ultimate Tensile Strength p.s.i.		150,000	- 190,000
Elongation in 2" (Proportional to U.T.S.)	CLASS 1.	150 - 165 M	-- 25 - 20%
	CLASS 2.	165 - 180 M	-- 20 - 15%
	CLASS 3.	180 - 190 M	-- 15 - 10%
Grain Size (Equi-Axed Structure)		.005 m m .	Max.
Diamond Pyramid Hardness (200 Gr. Load)	CLASS 1.	340	- 360
	CLASS 2.	350	- 370
	CLASS 3.	370	- 390
Knoop Hardness (100 Gr. Load)	CLASS 1.	330	- 350
	CLASS 2.	340	- 360
	CLASS 3.	360	- 380
Proportional Limit (% of U.T.S.)		80	- 90%
Spring Force Applications (Max. Recommended)		60 % of Prop. Limit	
Stability during Ageing		STABLE	
Creep under sustained load within prop. limit -		NIL	
Angle of Set			20°

FULLY AGED

Modulus of Elasticity		17 x 10 ⁶	
Ultimate Tensile Strength p.s.i.		175,000	- 200,000
Elongation in 2"		10 %	- 5%
Grain Size (Equi-Axed Structure)		.007 m m .	Max.
Diamond Pyramid Hardness (200 Gr. Load)		380	- 410
Knoop Hardness (100 G Load)		370	- 400
Proportional Limit (% of U.T.S.)		80	- 95%
Angle of Set			22°
(Creep under sustained load within prop. limit)		NIL	
Spring Force Applications (Max. Recommended)		60 % of Prop. Limit	

SEVERAL FEATURES BECOME IMMEDIATELY OBVIOUS

1. Elongation has been increased.
2. The hardness limits can be controlled to ± 15 KHN_{100g} numbers from any desired nominal.
3. Brittleness is minimized even in the hardest tempers.
4. Complete recrystallization can be achieved without excessive grain growth.
5. Controlled ageing can produce relatively hard tempers and high tensile strengths without undue loss of formability.
6. Resistivity (ohm/cm².) has been lowered slightly.

DESIGN CONSIDERATIONS

L&G #226 has a relatively low electrical conductivity. For this reason, this alloy is primarily employed in small components handling light electrical loads where the mass is sufficient to compensate for the high resistivity.

In the Age Hardened condition, this alloy has high wear resistance against all the nickel chromium resistance wires.

Where spring forces are involved, the safe working factor is about 60 % of the Proportional Limit.

SELECTION OF TEMPER

L&G #226 Alloy can be Solution Annealed and subsequently Age Hardened to high values. The proper temper to order is dependent upon subsequent forming operations as well as the desired ultimate hardness values.

Annealed stock may be furnished in temper ranges of 200 KHN₁₀₀ to 230 KHN₁₀₀. Within this range severe forming can be performed. If considerable cold work has been done, it is almost mandatory that re-solution annealing must be performed prior to Age Hardening. Failure to do this may result in over-aged sections where severe cold working has been done with resultant fracture upon bending.

General Findings Inc. has perfected procedures which make it possible to partially age L&G #226 and subsequently continue ageing to the full value of temper. This procedure is advantageous where parts require additional operations, but can easily distort if handled in the Solution Annealed condition which may have been necessary for primary heavy forming.

Our specialized new equipment can effect economies to users of L&G #226 by providing both wire and strip, age hardened in continuous lengths and shipped on large diameter reels. This stock will pay off straight with no spool set. Simple forms may then be cut or blanked with minimum end loss formerly encountered in the customary one (1) ft. straight lengths. Feeding rate is increased materially and automatic blanking can be instituted.

An erroneous terminology has crept into use through misunderstandings of the true characteristics of this alloy. This term is "Age Hardened - Stress Relieved." Because stress relief of cold work strains occurs at the same temperature ranges as Age Hardening, the reactions go on simultaneously making temper and tensile strength control virtually impossible. It appears from the records that the purpose of this terminology has been the desire to retain hardness and spring properties with formability.

Now it is no longer necessary to use this terminology. General Findings Inc. and Leach and Garner Co. cooperated to produce the new Ductile Grade #226. This new grade is Age Hardened to levels of KHN₁₀₀ 340-380 while maintaining elongations of 10 - 25%. Tensile strengths are well above the former call out of 140,000 p.s.i. minimum.

Further controls have been instituted to provide practically all desired tempers from K100 - 340 up with tolerance of ± 15 points KHN₁₀₀. Where special conditions exist that require a more uniformly exact temper, General Findings Inc. can furnish a temper controlled to ± 5 Knoop Hardness numbers at special prices.

In summary, therefore, consideration of the desirable hardness values and/or tensile strength values, coupled with the amount of cold forming or angular deflections desired, should dictate the level of ageing in the Ductile Grade and material should be ordered accordingly.

For example ... a wire brush form that must be bent after molding and still possess high spring factors and wear could be ordered as:

L&G #226 Wire .008" Ductile Grade

KHN₁₀₀ 370 ± 15

Minimum Tensile 155,000 p.s.i.

ONLY GENERAL FINDINGS' L&G #226 CAN MEET THESE SPECIFICATIONS

Where sections are small and where cost is secondary, the contact and contact arm can be made integral, eliminating costly welding and joining operations.

Where heavy construction is required, it is usually advisable to revert to the two (2) piece construction to reduce excessive use of the costly alloy. In such cases L&G #226 can be easily soldered, welded, riveted or otherwise mechanically joined to such metals as phosphor bronze or beryllium copper.

Surface finish as produced by our Rolling mills is usually sufficient to meet micro-inch finish requirements. This surface is maintained throughout annealing and age hardening by specially designed furnaces and ovens. Higher finishes may be obtained by added operations such as tumbling or polishing.

Corrosion resistance of L&G #226 is very high due to the nobility of 75% noble metals. Shelf life is excellent and service life exceedingly good in all normal atmosphere environments.

The designer should consider certain limitations as follows:

1. Provide bends with radii as large as possible. But, in no case, should bends be of a radius less than the stock thickness or wire diameter.
2. Avoid draw depths greater than 4x metal thickness.
3. In forming dimples and daps, the arc of such should not exceed 30% of the subtended chord length.
4. Values published herein will not hold on thickness of less than .002" or wire diameters under .005".

TYPICAL APPLICATIONS

L&G #226 Alloy used as brushes and wiper arms on precision potentiometers is unexcelled against nichrome and related resistance wires. Aged to the lower tempers, it is very satisfactory as sliding contact in potentiometers with coils of maganin wire.

High corrosion resistance with stable high level spring properties make this alloy ideal for light loads and low noise levels. It may be used successfully on collector rings of coin silver, L&G #201, L&G #205 and electroplated hard nickel.

L&G #226 also finds ready application as sliding contacts against printed circuits of copper-nickel-rhodium. Proven life of many millions of cycles has been obtained proportional to cycle speed and length of wear path.

On low voltage, low to medium amperage, L&G #226 is excellent as "make and break" contacts. This is due to its resistance to oxide or sulphide corrosion, its high initial hardness which prevents impact deformation and high melting temperatures for resistance to arc erosion.

L&G #226 will find additional uses as precision cam followers, pivot bearings and instrument shafts where ferrous products will not do or where non-magnetic material must be used.

NOW...FOR THE FIRST TIME

General Findings Inc. shares with you, our valued customers, comprehensive graphs of the superior performance of L&G #226. Such information as herein published is usually proprietary, but we feel that your engineers and designers should have this information to more clearly understand the physical behavior of L&G #226.

These graphs illustrate only a small portion of the breadth and depth of our research into this alloy. For many years all suppliers produced a "good enough" product until General Findings Inc. decided that high reliability, consistent spring forces and uniformity of wear required something better than "good enough."

Mention has been made of our new improved processing procedures, the results of which are herein described. These procedures could not be performed without the specially designed furnaces and ovens which were built to our specifications. This equipment is unique. The primary furnace controls the Solution Annealing and provides for the strip or wire to literally float through the furnace in a continuous flow and to be quenched in periods from 1/10 to 1/2 second from optimum temperature ... all under precise control of time and temperature. Auxiliary ovens control Ageing rates precisely in gas or vacuum, either continuously or in batches. Our new equipment and development time represents many thousands of dollars and hundreds of man hours.

We believe the results of our expenditure in time and money are evidenced by the completeness of this technical bulletin.

YOUR FIRST CONSIDERATION, THEREFORE, WHEN SPECIFYING STOCK OR PARTS OF L&G #226 SHOULD BE GENERAL FINDINGS INC. WHERE METALLURGICAL PROGRESS KEEPS PACE WITH INDUSTRY'S NEEDS.

PLATE NO. 1

The effect of uncontrolled grain size is illustrated. The hardness values have been lowered, coarse intergranular precipitation is progressively evident. Brittleness is present and fracture strength lowered.

Compare the above Plate #1 to Plate #2 (below). The above condition is frequently encountered in regularly supplied stock. General Findings Inc.'s new improved processing techniques produce a consistently superior product, as shown in Plate #2.

PLATE NO. 2

General Findings new process L&G #226. Note the uniform fine grain, the smooth hardening curve. Also, note the absence of visible precipitation. Yet, this alloy has been completely solution annealed with no evidence of residual cold worked structure.

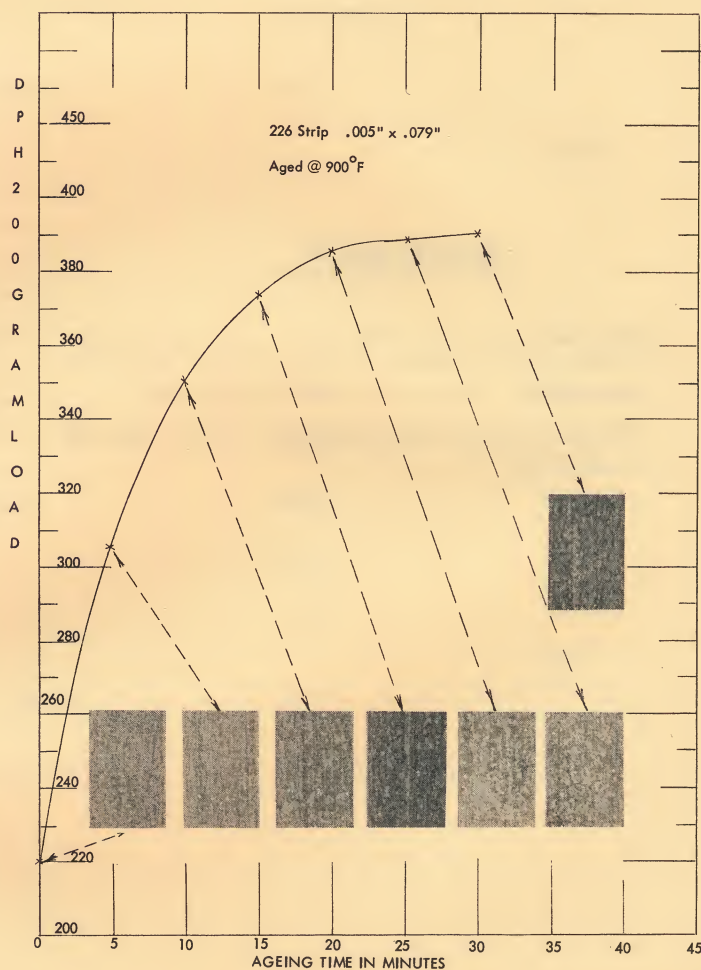
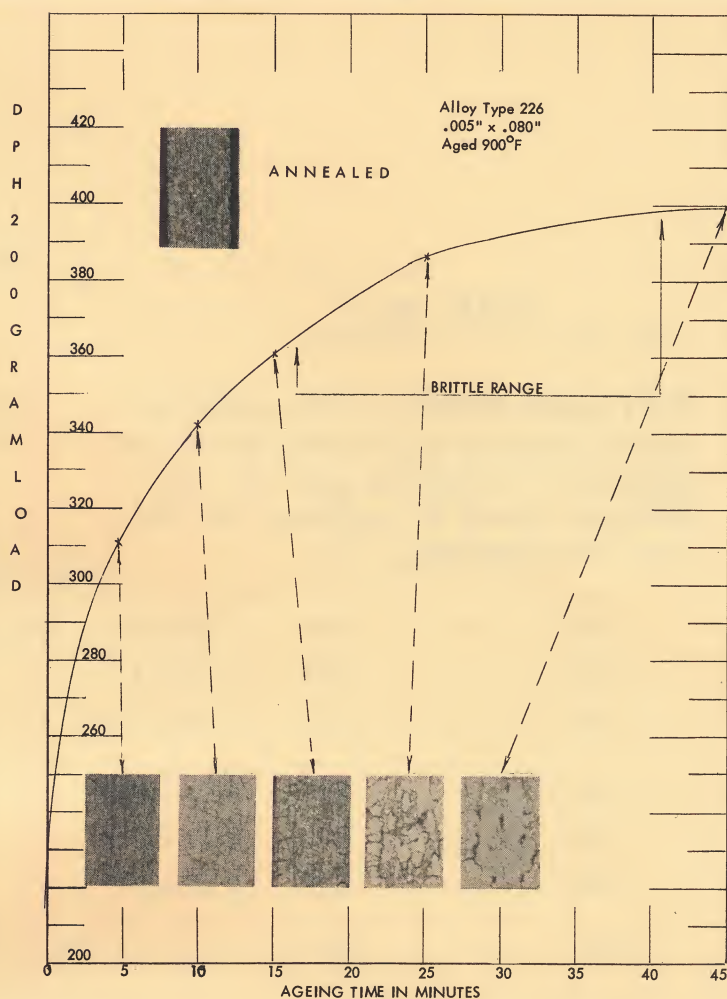


PLATE NO. 3

This graph illustrates the effect of various ageing temperatures on the percent of elongation and the comparative speed of response for various time periods.

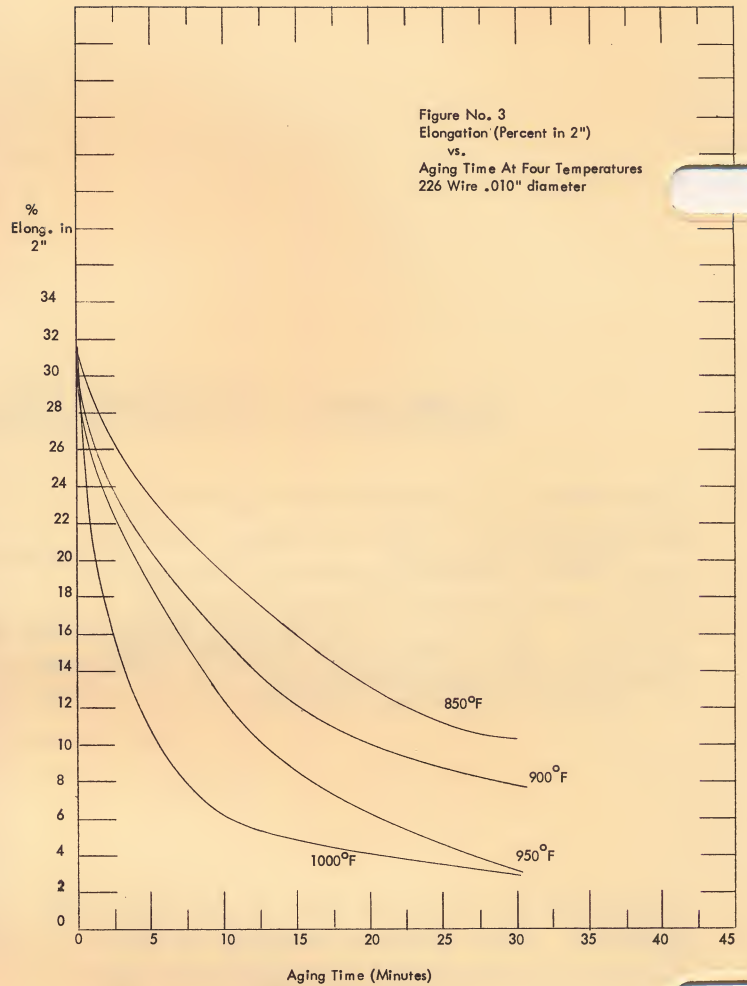


PLATE NO. 4

Composite graph from which tensile strength, proportional limit and elongation can be picked when ageing at 900°F.

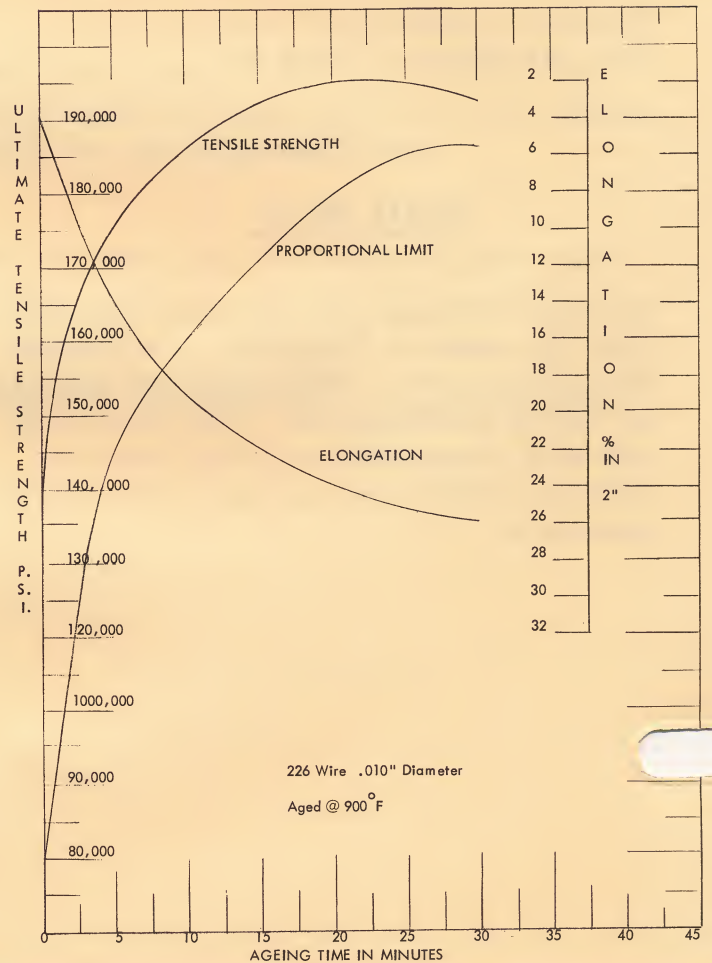


PLATE NO. 5

Ageing time vs. Temperature. The difficulty of selecting proper ageing time is readily apparent in the case of 1000°F. Over ageing with concomitant loss of tensile strength and brittleness is manifest.

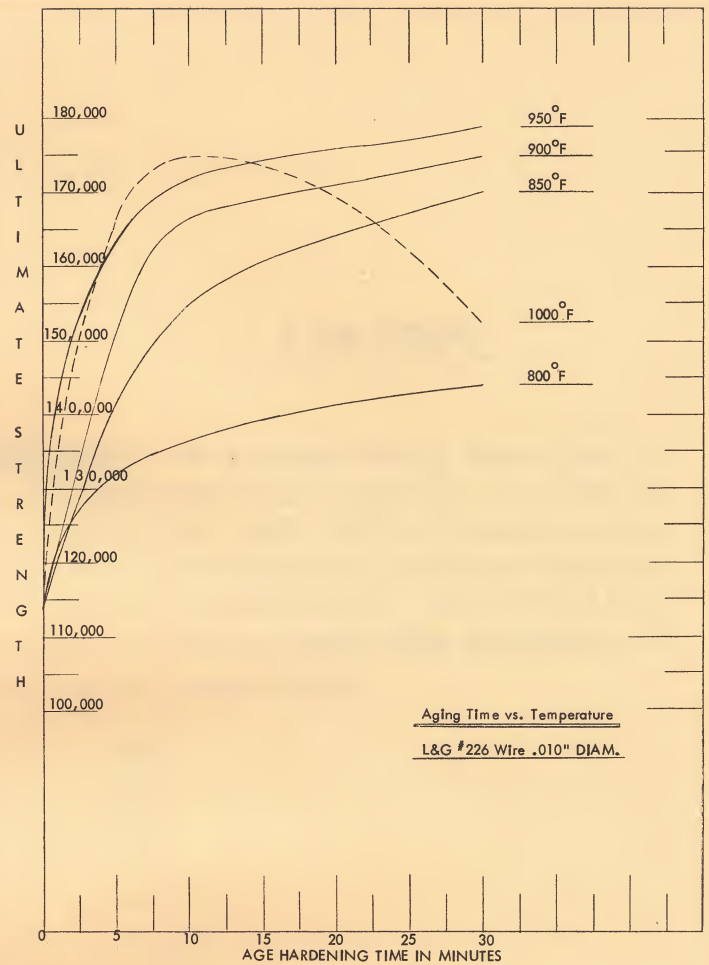


PLATE NO. 6

This graph shows the essentiality of controlling the initial solution anneal if subsequent ageing must meet exacting requirements in the finished product.

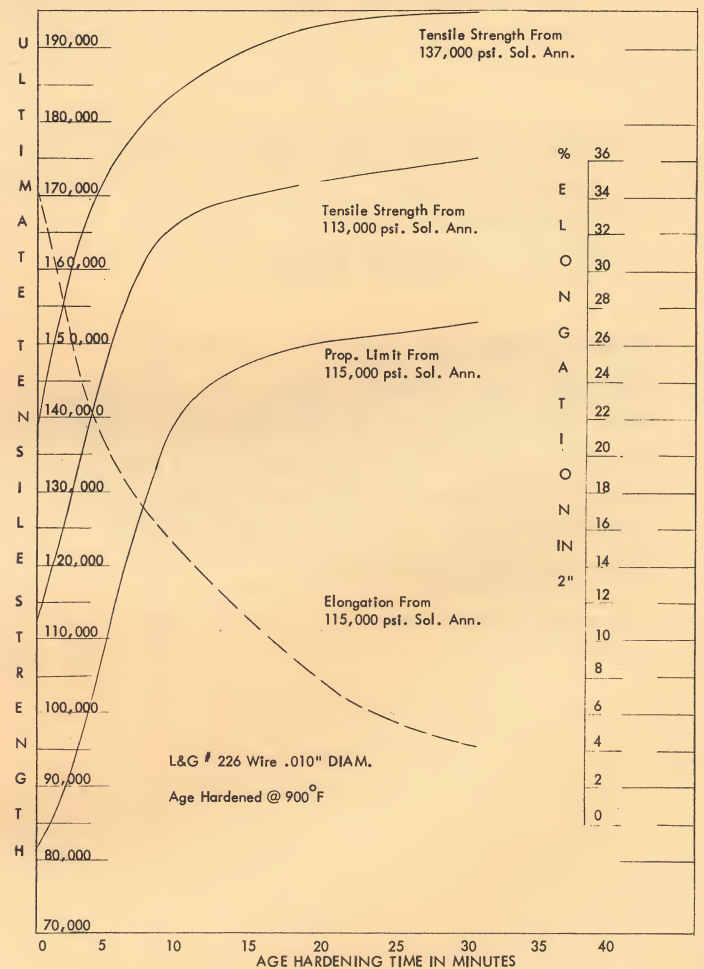


PLATE NO. 7

A composite graph showing the effect of time at a series of selected temperatures based on #226 alloy wire which has been solution annealed to U.T.S. of 113,000 psi. Comparative changes in elongation are also illustrated.

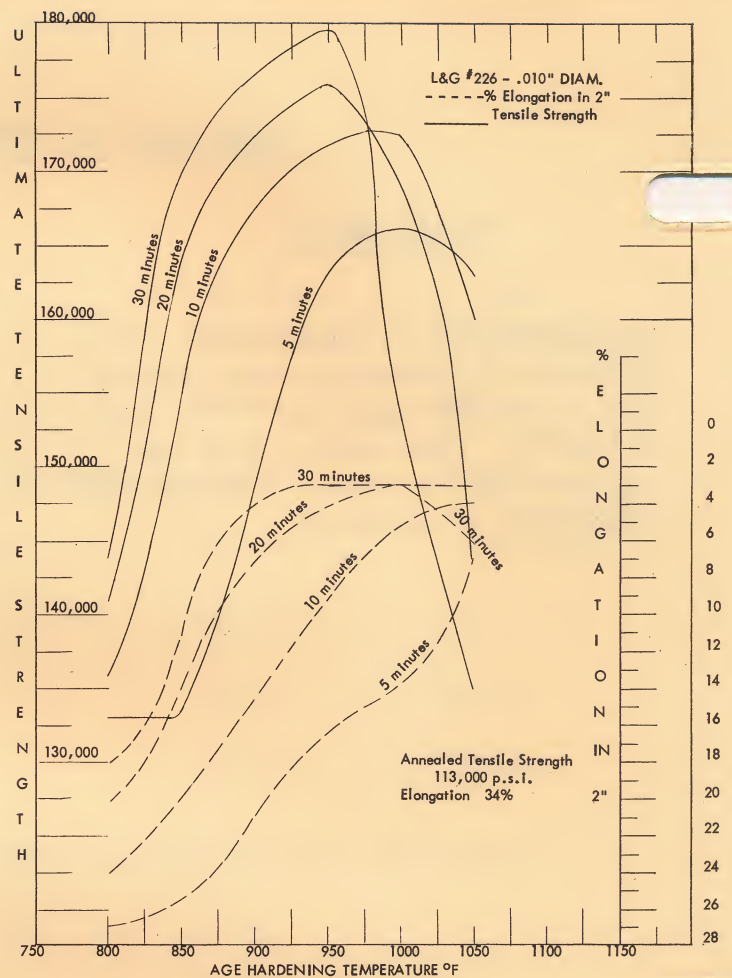
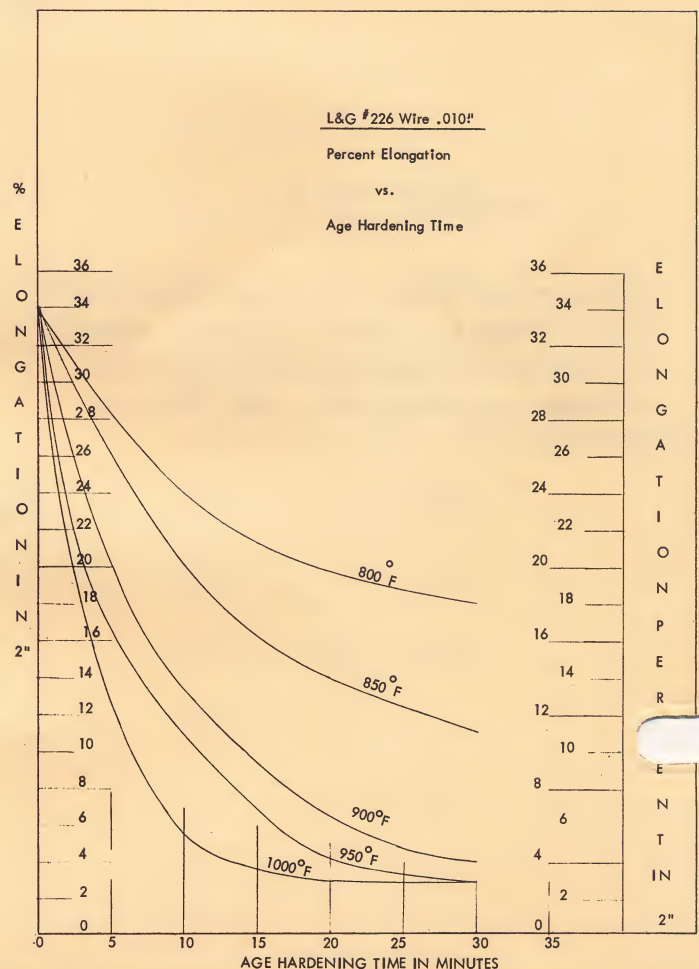
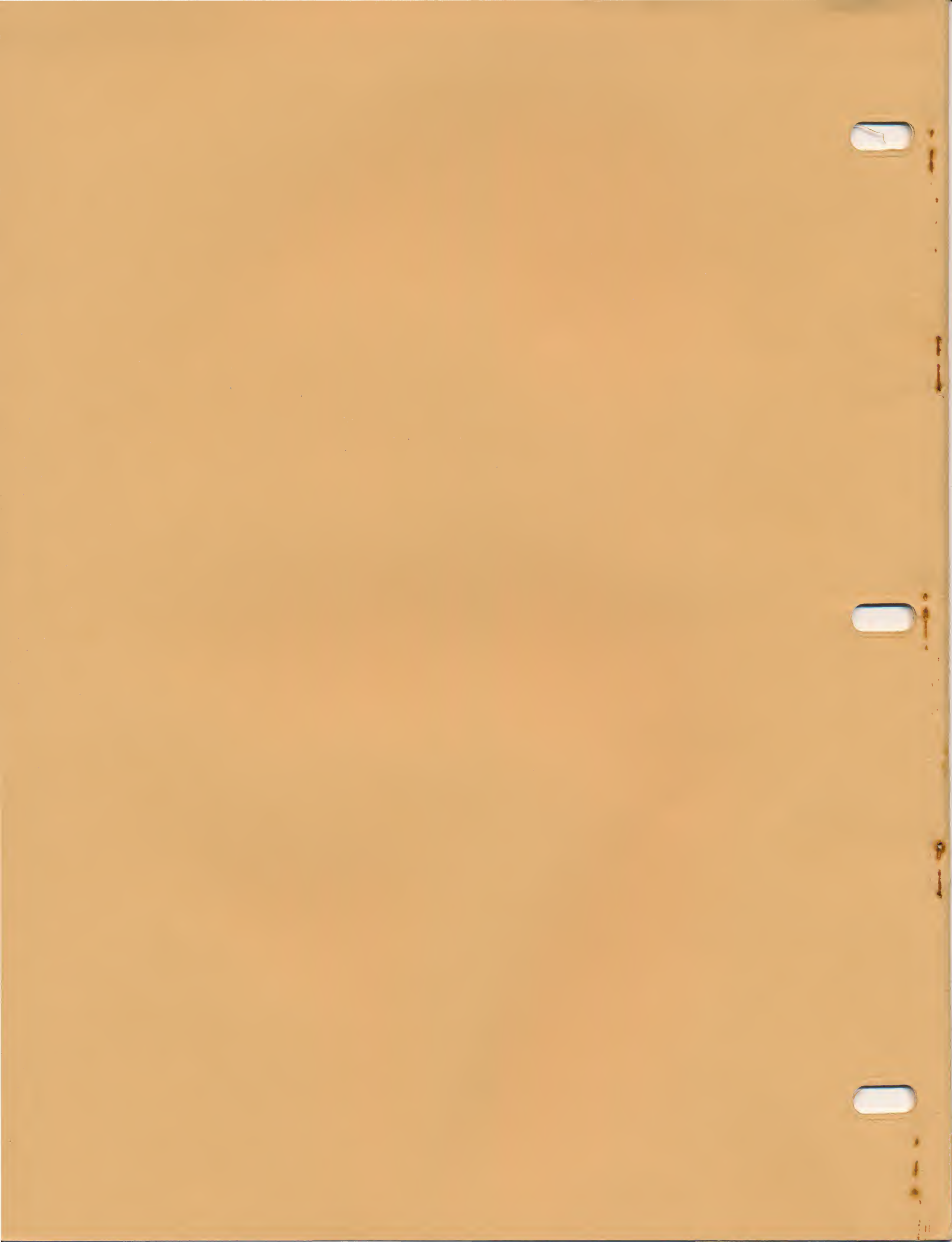


PLATE NO. 8

How elongation can be controlled through the proper selection of time and temperature is graphically illustrated. By determining the proper initial temper, it is thus possible to determine the ultimate formability that will be produced.





NEW ALLOYS OFFER WIDER RANGE OF PHYSICAL PROPERTIES



TECHNICAL BULLETIN #211 — #212 — #213

GENERAL FINDINGS INC.

MAIN PLANT

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WEST COAST PLANT

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NO. HOLLYWOOD, CALIF.



TECHNICAL BULLETIN #211 — #212 — #213

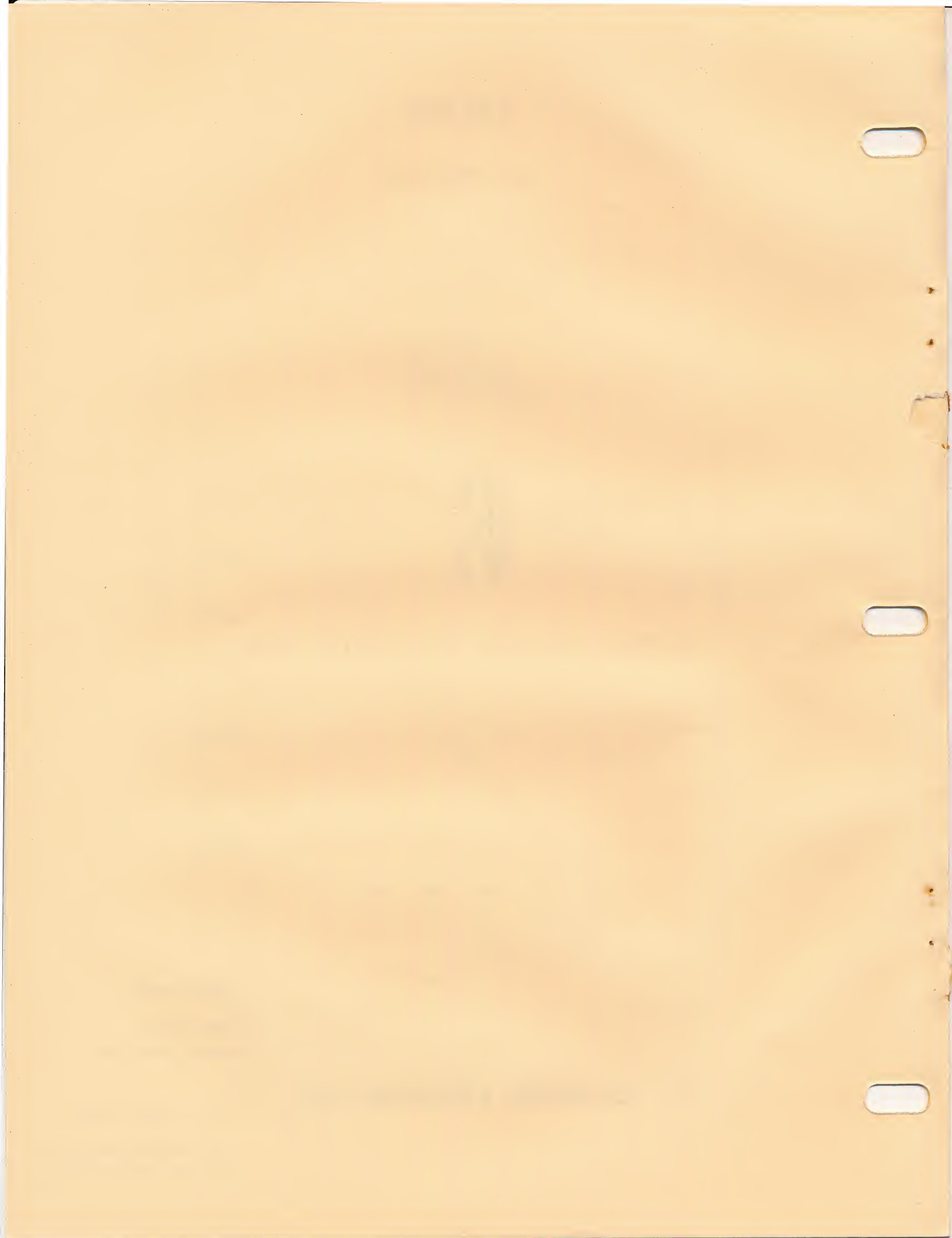
GENERAL FINDINGS INC.

MAIN PLANT

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INTRODUCTION

It is well recognized that 24K Gold would be highly desirable for contact use were it not for its poor wear characteristics, its lack of resilience and its susceptibility to cold welding and galling. The metal does not form oxides or sulphides and does not promote film formations.

In the absence of film formation, noise levels remain low and shelf life is excellent. To improve the detrimental characteristics, many alloys have been tried to retain the desirable features while improving those that are undesirable. The addition of Silver and/or small amounts of Nickel produces this series of fine Gold substitutes known as Leach and Garner Alloys #211, #212 and #213.

Basically these alloys are all 18K Green Gold of the following composition:

	<u>Gold</u>	<u>Silver</u>	<u>Nickel</u>
L&G #211	75%	25%	---
L&G #212	75%	22%	3%
L&G #213	75%	23-1/2%	1-1/2%

The addition of Nickel to the basic 75-25 Gold-Silver alloy improves wear resistance and spring properties. The 3% Nickel alloy (L&G #212) carries the ASTM designation H-7.

None of the three alloys is age hardenable. Hardness and spring tempers are imparted by cold work only.

The percent of cold work required to produce desired tempers does not follow the common terminology for specifying spring tempers, i.e., 8 B&S numbers as spring hard, or 12 B&S numbers as extra spring hard. These alloys show an expected hardening curve up to 4 B&S numbers cold worked. The curve then levels off to 10 B&S numbers; thereafter, additional cold work produces a resumption of temper increase with additional area reduction. This phenomena is not fully understood.

PHYSICAL PROPERTIES OF L&G #211 — #212 — #213

	<u>211 CW</u>	<u>212 CW</u>	<u>213 CW</u>
Resistivity, ohms/cm nominal	61	73	73
Conductivity - % IACS	16.7	14.2	14.2
Density (dwt./cu. in.)	168.7	167.8	167.2
Temperatures of Fusion	1920	1920	1920
Coef. of Linear Expansion /°C (50-200)	8.7×10^{-6}	8.3×10^{-6}	8.2×10^{-6}
Modulus of Elasticity p.s.i.	12×10^6	12×10^6	12×10^6
Proportional Limit (see curves)			
Ultimate Tensile Strength p.s.i.			
(see curves for relation of Tensile Strength to Cold Work)			
Elongation			
(see curves for relation of Elongation to Cold Work)			
Knoop Hardness (100 Gram Load)			
(see curves for relation of hardness to Cold Work)			

SELECTION OF TEMPER

Within the physical limits of the alloy tempers may be had over the full range; however, tubing has limitations governed by the desired diameter and walls.

The drawing of seamless shells for ultimate use as tubing provides relatively thin walls. Therefore, it may not be possible to produce the desired tempers as the percent of cold work is definitely limited to the available diameters and wall ratios of starting size to finished size.

The graphs included in this bulletin illustrate the anticipated range of tempers that may be attained in wire and sheet.

Although these alloys exhibit low elongation in the hard condition, they still retain high ductility and can be formed and bent readily over relatively small radii.

USES

L & G ALLOY #211

L&G #211 is used on sliding contacts in button or wire form where extremely high reliability is required. Its resistance to tarnish and corrosion is excellent and, when sealed against foreign environments, maintains its low level of surface resistance over long service periods.

L&G #211 is not recommended where wear is a factor. Its best use is in maintaining its initial low level resistance through intermittent use. It is not sufficiently hard or strong to be used as a spring member but may easily be attached by conventional means to spring members.

L&G #211 is compatible for use with Silver and Silver alloys.

L & G ALLOY #212

The 3% Nickel alloy is the most widely used of this group. L&G #212 is the hardest of the group and is used as solid members for brushes and collector rings. Freedom from corrosion is excellent. Low level energy transmission is high and, as a collector ring, is long wearing against a wide variety of brushes such as L&G Alloys #205, #212 and #226. L&G #205 wears particularly well against #212 when it is necessary to plough through surface films to maintain low noise.

Against itself #212 wears in well with little residue and resistance drops and maintains very low noise levels with extended service.

L & G ALLOY #213

Intermediate in hardness between #211 and #212. L&G #213 substitutes for #211 where increased mechanical strength and wear are necessary.

As a sliding contact against soft resistance wires or over long sweeps, it will perform very satisfactorily.

GRAPHS OF L & G ALLOYS #211 — #212 — #213

As is our policy, we present herein graphs on the physical properties of L&G Alloys #211, #212 and #213. We believe it is more informative to present this information in this manner in order to better acquaint the user with the basic nominal test data for study, particularly where alloys such as these may have certain peculiarities exhibited by cold work, stress relieving and annealing.

While the values present are for wire, rod and sheet follow very closely to these curves. Further, this data concerns sizes in the range most commonly used.

With the information obtained from the following graphs, the alloy capabilities can be better understood and proper ordering specifications can be incorporated to obtain the specific tempers and physical properties most suited to your applications.

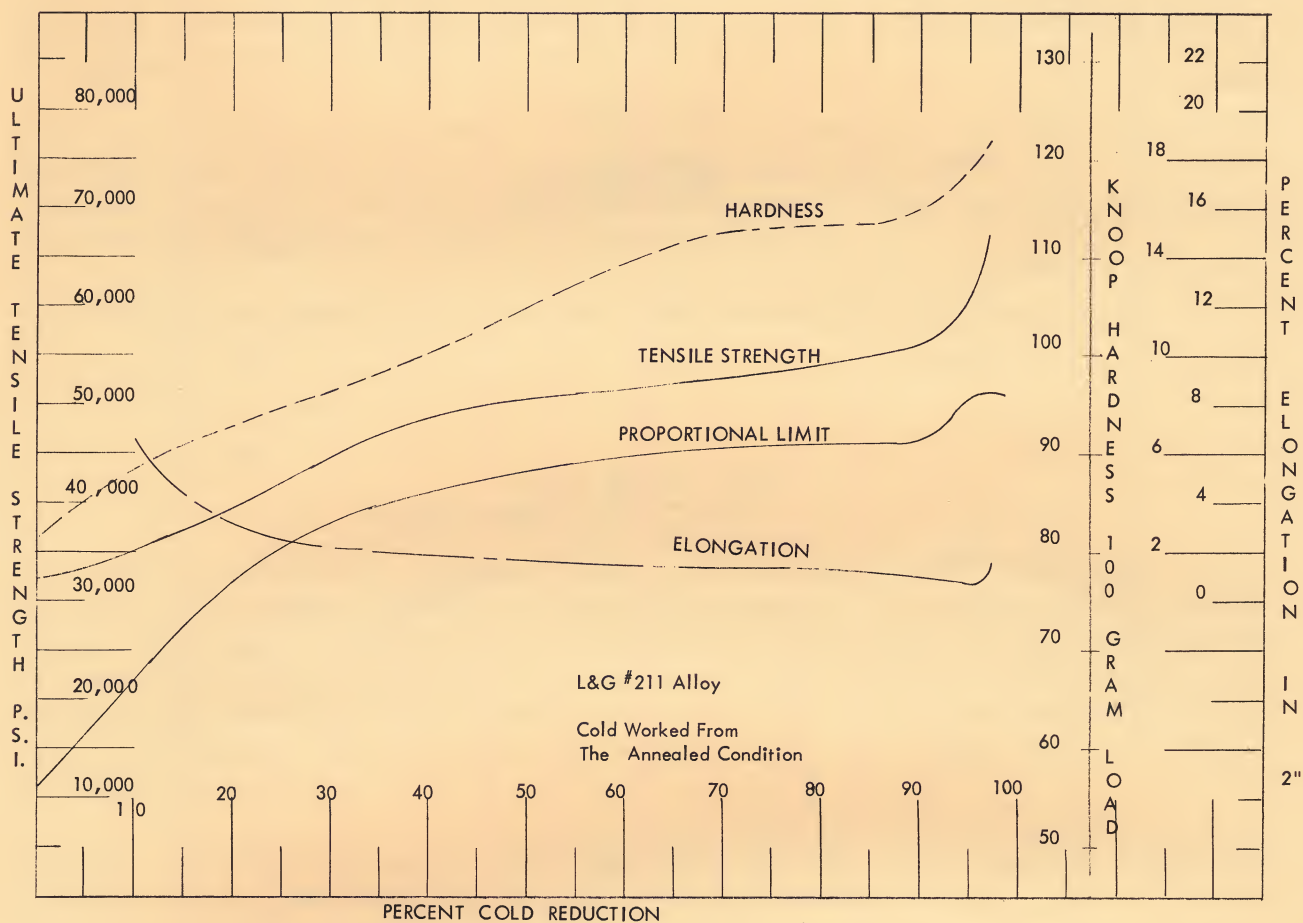
FORMS AVAILABLE

All mill forms are available in these alloys. Marketed through a Leach and Garner affiliate, General Findings Inc., L&G Alloys #211, #212 and #213 can be furnished to .001" gauge in sheet, to .005" diameter wire, as well as a wide variety of tubing sizes.

YOUR FIRST CONSIDERATION, THEREFORE, WHEN
SPECIFYING STOCK OR PARTS OF L & G #211, #212 AND #213
SHOULD BE GENERAL FINDINGS INC. WHERE METALLURGICAL
PROGRESS KEEPS PACE WITH INDUSTRY'S NEEDS

PLATE NO. 1

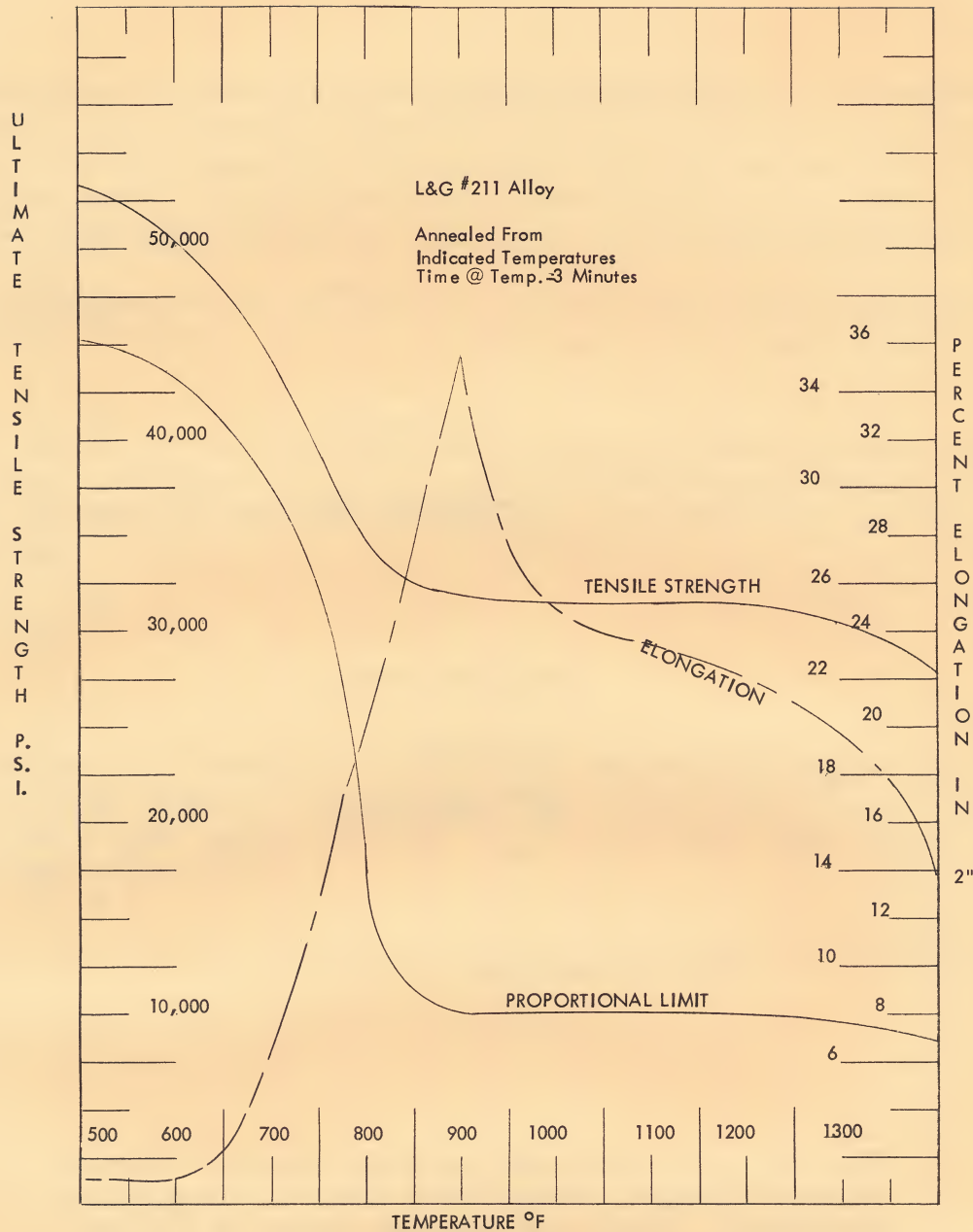
L & G ALLOY #211



The curves in this graph portray Temper, Ultimate Tensile Strength, Proportional Limit and Elongation (0 %offset). These are average values of several samples processed in the same manner. Note the sharp rise in Tensile Strength and hardness cold worked in excess of 85%.

PLATE NO. 2

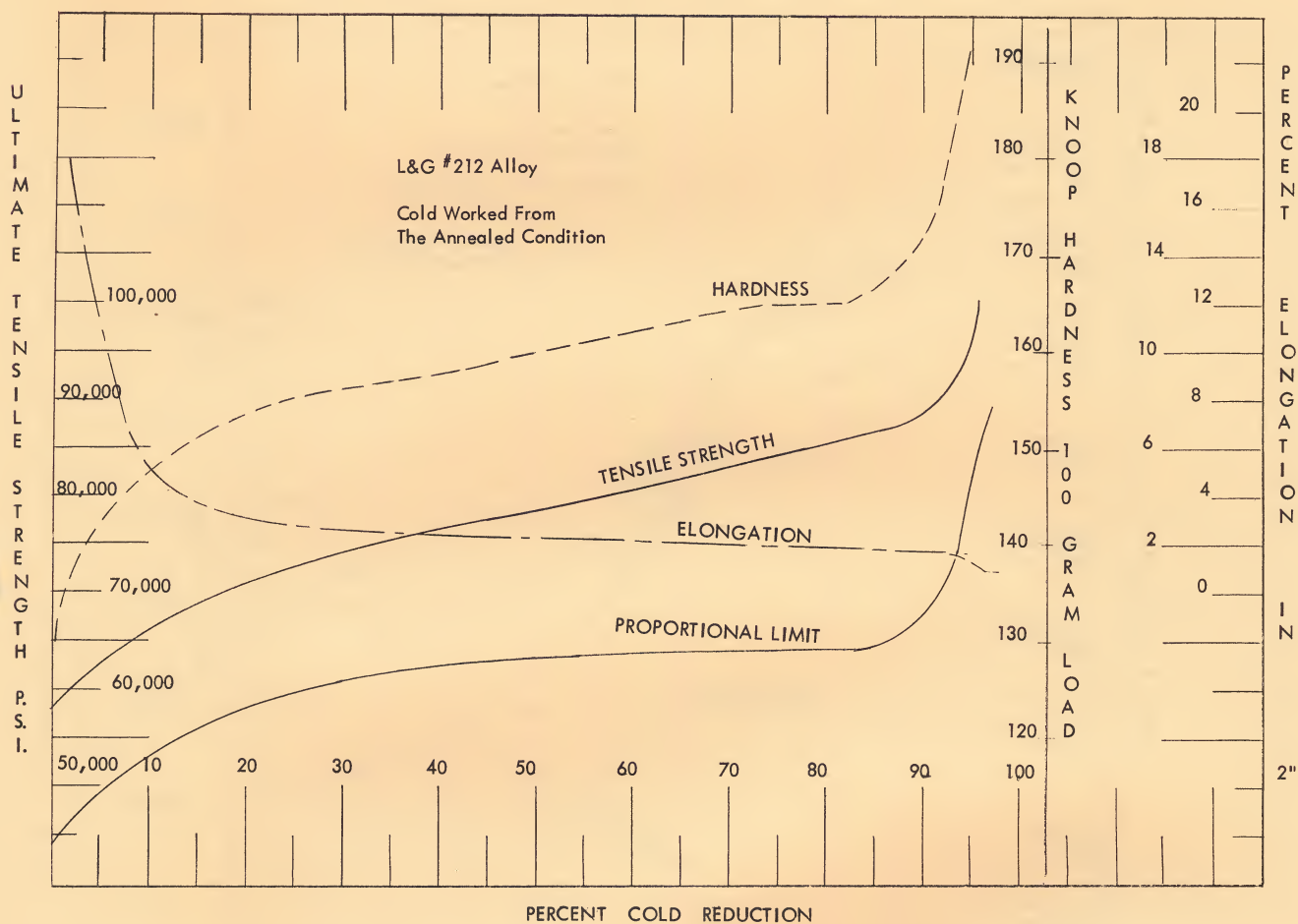
L & G ALLOY #211



This graph represents the response to annealing temperatures and depicts the anticipated hardness values, tensile strength and the proportional limits attainable. Annealing time is short (3 minutes at heat) and response rapid. Note the elongation curve. This is unusual, but is of interest when maximum formability is desired.

PLATE NO. 3

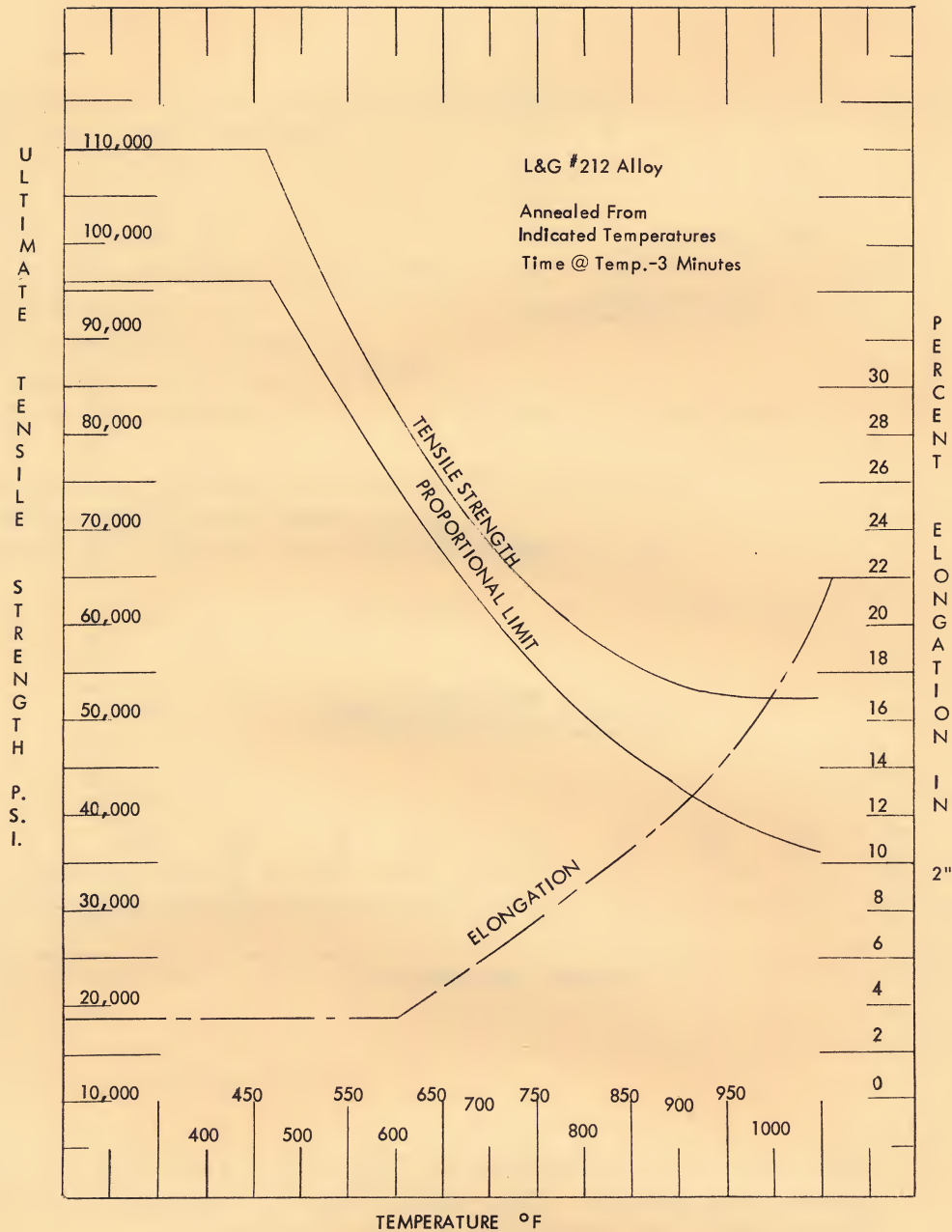
L & G ALLOY #212



The cold work properties of L&G #212 alloy are graphically shown. The sharp rise of temper above 80% area reduction is again evident as explained in the text under "Temper." Note the close correlation of hardness, tensile strength and proportional limit.

PLATE NO. 4

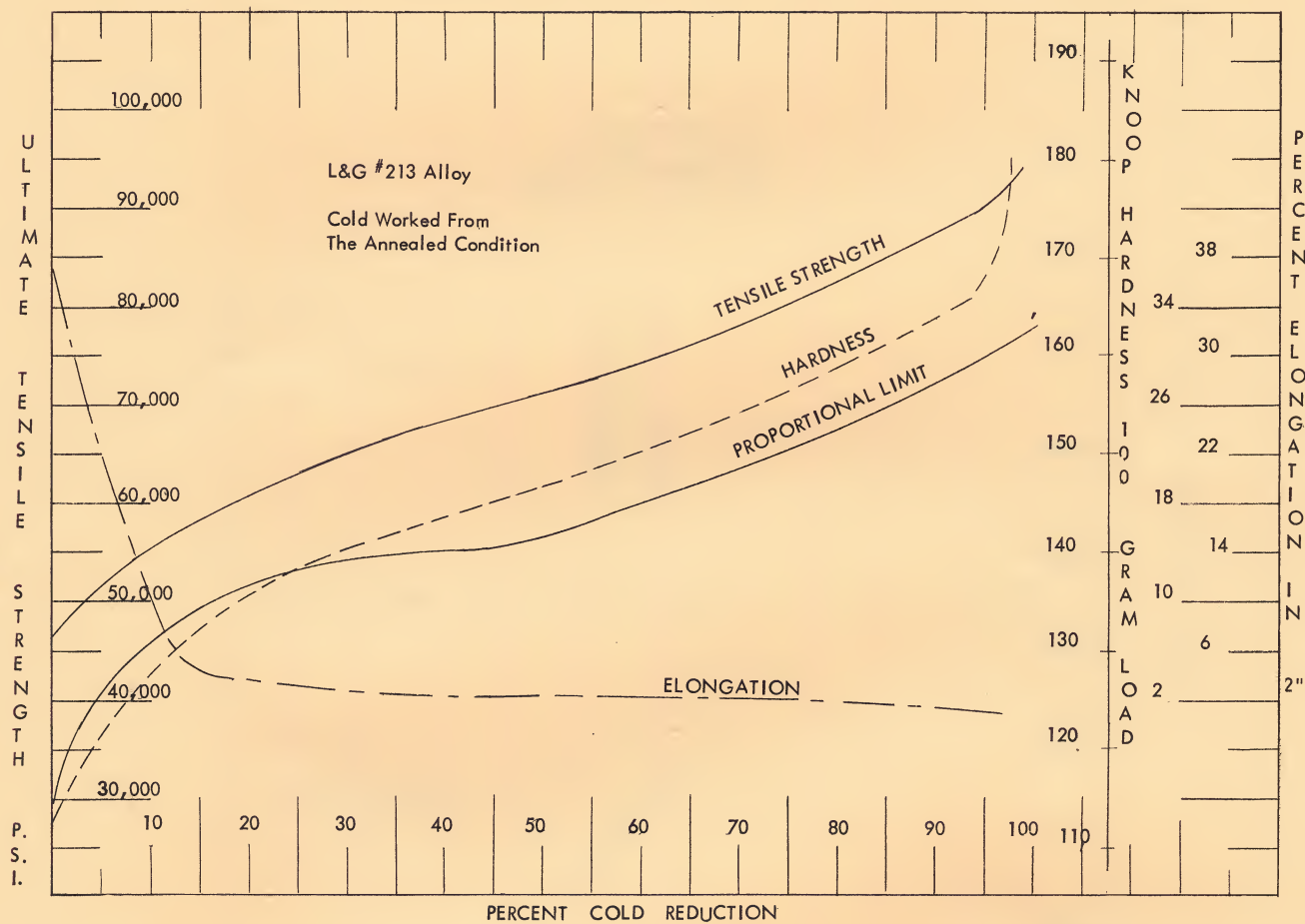
L & G ALLOY #212



Typical annealing curves of L&G #212 alloy. Temperatures indicate that use should be well under 400°F. Stress relief will take place at relatively lower temperatures (if the time at such temperatures is extended proportionally) with a consequent loss in spring properties.

PLATE NO. 5

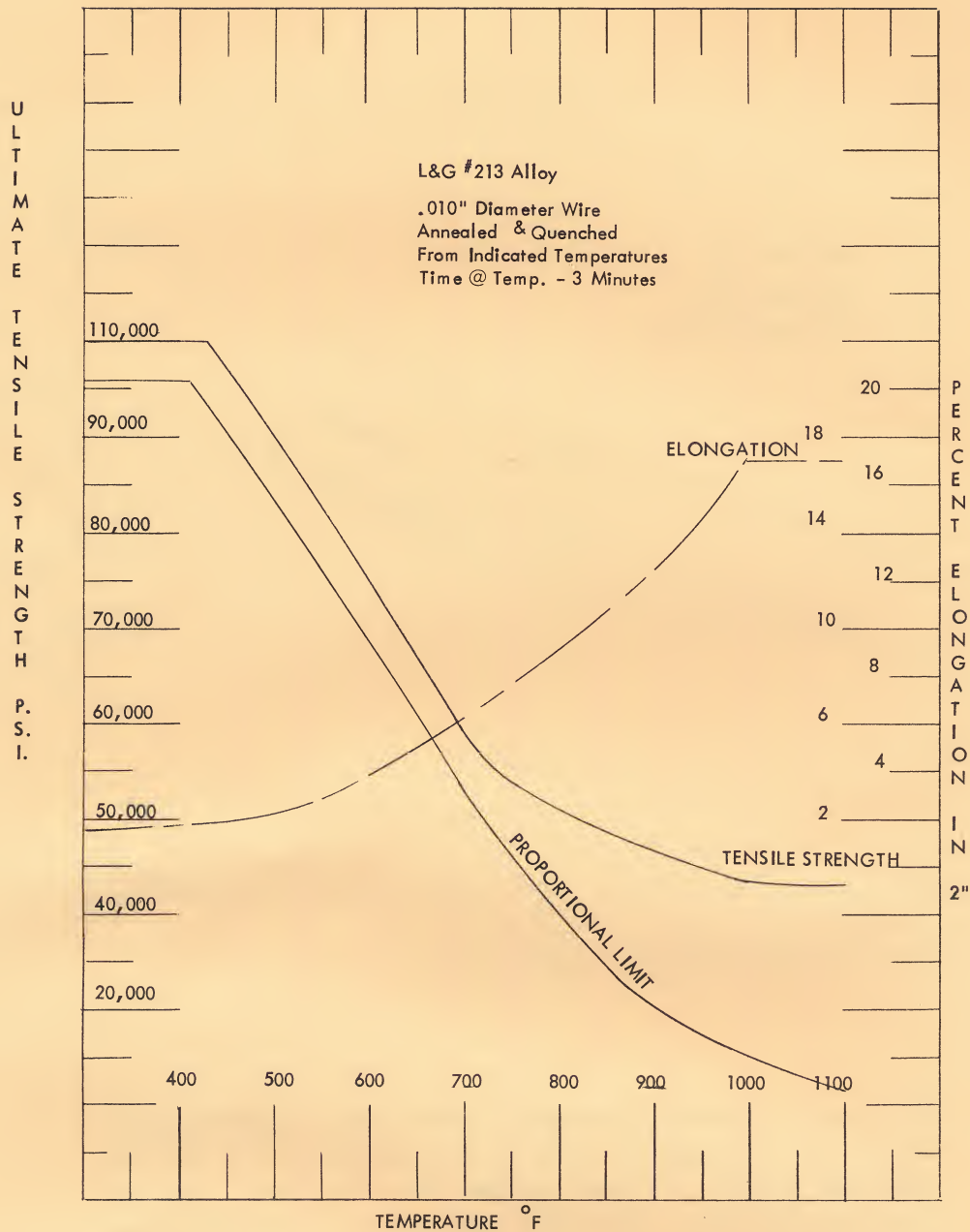
L & G ALLOY #213



Values of Tensile Strength, Hardness, Proportional Limit and Elongation may be derived from the accompanying graph. These values are nominal. As in previous graphs, these are sufficiently accurate for specification purposes on both wire and sheet. Equivalent values in tubing may not be attained in the higher hardness and tensile ranges because of limited starting walls on the seamless shells.

PLATE NO. 6

L & G ALLOY #213



The effect of annealing temperatures on #213 alloy shows the rapid relief of stresses and subsequent recrystallation as temperatures rise. Sustained heat in the 400° - 450° range will produce a decided drop in tensile strength and a proportional increase in elongation.

